Impulse in 2-Dimensions

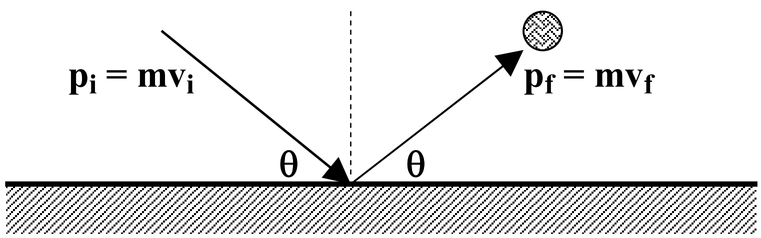
Momentum is a vector quantity. When the velocities are not along the same line (i.e., positive or negative), vector adding must be done. In the following case, a ball with an initial momentum is given an impulse by the wall that it strikes, and this results in a new final momentum as well as a change in the ball's direction.

Remember that impulse is equal to change in momentum, so

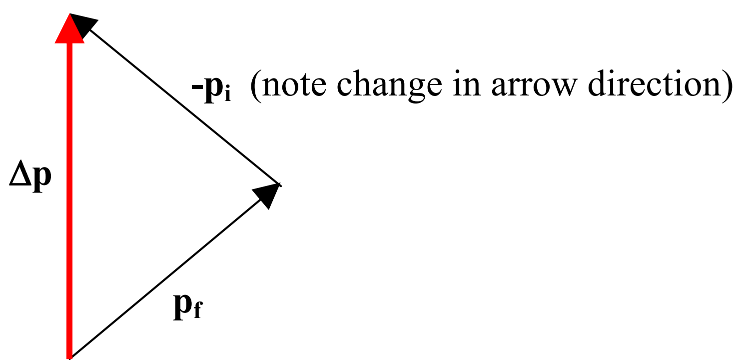
$$\Delta \mathbf{p} = \mathbf{p_f} - \mathbf{p_i} = \mathbf{p_f} + -\mathbf{p_i}$$

Using vector analysis, this equation shows that impulse is the resultant of the vector addition of $\mathbf{p_f}$ and $-\mathbf{p_i}$.

Start with a diagram of the situation, showing initial and final momentum vectors:



Next, vector-add $\mathbf{p_f} + -\mathbf{p_i}$ and draw the resultant vector $\Delta\mathbf{p}$:



Note that the impulse acts perpendicular to the surface of impact. In fact, the impulse acts in the same direction as the force of the surface on the object. This should not be surprising, since

$$\Delta \mathbf{p} = \mathbf{F}\Delta \mathbf{t}$$

Example #13: A 2.0 kg ball going 10 m/s bounces off a wall at an angle of 40º to the wall. (Both incoming and outgoing angles are 40º). After the bounce the speed is still 10 m/s.

a) What is the impulse on the ball?
b) What is the change in velocity?

(see Momentum Ex 13 for answer)

Finally, the formula $\mathbf{\Delta p = p_f - p_i}$ can be re-arranged to read $\mathbf{p_f = p_i} + \Delta\mathbf{p}$. In other words, the vector addition of initial momentum and impulse produces the resultant final momentum. Use this approach on problems where both initial momentum and impulse are given.